FLUKE®
Biomedical

Victoreen® 07-479

Dental Digital kVp Meter

Operators Manual

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Fluke Biomedical
Radiation Management Services

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Section 1
Introduction

1.1 Product Description

The Model 07-479 Dental kVp Meter is designed to measure the effective peak potential applied to dental type x-ray tubes. The measurement is made without direct connection to the x-ray unit being tested. The kVp Meter is a battery powered, self-contained instrument designed for portable use.

The kVp meter uses two differentially filtered detectors whose ratio of integrated outputs is calibrated over the range of 45 to 90 kVp. Measurement results are presented on an easy to read 3 ½ digit liquid Crystal Display. Status is indicated by decimal point positioning on the readout. Low battery condition is indicated by LO BAT displayed on the readout.

1.2 Specifications

Range	45 to 90 kVp
Accuracy	± 3 kV or 3%, whichever is greater. Calibrated with NBS traceable voltage divider.
Reproducibility	± 0.5 kV
Resolution	0.1 kV
Distance Dependence	Negligible for SSD of 20 cm or greater
Angle Dependence	Negligible for 10 degrees or less
Position Dependence	Negligible for misalignment of 5 cm or less at 30 cm
Calibration Period	One year
Minimum Requirements	5 mAs @ 45 kVp (20 cm) 0.03 mAs @ 90 kVp (20 cm)
Power Requirements	9 V Alkaline Battery, MN1604A or equivalent
Display	3 ½ Digit LCD **Low Battery Indication:** LO BAT **High kV Indication:** Left blinking decimal **Lo kV Indication:** Middle blinking decimal **High Intensity Indication:** Right blinking decimal and non-zero display **Low mAs Indication:** Right blinking decimal and zero display
LED Indicator	Auto Reset, new exposure detected, and last reading cleared.
Controls	**Front Panel:** Power switch and phase selection switch.
Output Connector	BNC Connector on rear panel for waveform output.

Dimensions (HxWxD)	2.5 x 8 x 6 in (6.4 x 20.3 x 15.2 cm)
Weight	2.1 lbs (.95 kg)
Operating Temperature	+18° to +40°C (+64° to +104°F) Maximum 90% relative humidity, non-condensing
Storage Temperature	-18° to 55°C (0° to +132°F)

1.3 Receiving Inspection

Upon receipt of the kVp meter:

1. Inspect the carton and its contents for damage. If damage is evident, file a claim with the carrier and notify Fluke Biomedical, Radiation Management Services at 440.248.9300.
2. Remove the unit from the packing material. Verify that the following items have been received and are in good condition:
   - (1) Model 07-479 Dental kVp Meter, P/N 164000
   - (1) MN1604A (or equivalent) 9 V Alkaline Battery, P/N 16-29
   - (1) Model 07-479 Operator's Manual, P/N 165001

If any of the listed items are missing or damaged, notify Fluke Biomedical.

1.4 Storage

If necessary, the kVp meter may be stored in an area free of corrosive materials, temperature and humidity fluctuations, vibration, and shock. In addition, the storage area should satisfy the environmental specifications of the unit.

Section 2
Theory of Operation

2.1 General

The kVp measurement is computed basically from a measurement of the linear absorption coefficient (MU) of the hardened x-ray beam. As the kV increases, the linear absorption coefficient decreases.

An x-Ray beam is composed primarily of two parts, the bremsstrahlung radiation and the characteristic radiation. For a sufficiently hardened beam, if a plot is made of the log of the kV vs the ratio of the bremsstrahlung part of the beam, a nearly straight line would result.

2.2 Filtration Effects

A slight change in the beam spectrum being measured will cause a change in the linear absorption coefficient. Such a change can be caused by filtration differences with respect to the calibration beam. With lower filtration, the x-ray beam will not be as hard as the calibration beam and the results will be lower. With more filtration, the beam will be harder than the calibration beam and the results will be higher.

2.3 Waveform Effects

Beam spectrum changes occur with different waveforms. A single-phase waveform, as opposed to a three-phase waveform, displays an approximate 5% change in readings. Correction for this is made by selecting the appropriate phase switch position. The Phase switch is located on the front panel. If loading on the generator causes the waveform to appear in the classic manner, the switch should be positioned in the three-phase position. In some situations, the waveform may be somewhat between the single phase and the three phase positions and the results may be compromised.

2.4 Low Battery

The low battery indication is displayed when the battery voltage drops below a predetermined value. This value is selected such that there is not a noticeable effect on the measurement results. Use of the instrument below this value (i.e. while the LO BAT indication is displayed) may result in erroneous measurements due to the loss of an accurate voltage reference.

2.5 Positioning Error

The kVp meter should be positioned in the center of the beam. The measurement area of the meter is two square inches. If measurements are made in other parts of the beam, different results will occur since the beam spectrum is different at different locations. The accuracy of the kVp meter will be compromised. The heel effect results in a beam spectrum change. To view the effects of beam positioning on the measurement, the user may want to position the meter in various parts of the beam for illustration purposes.

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Section 3
Installation and Setup

3.1 Installing/Replacing the Battery

Use the following procedure to install/replace the 9 V Alkaline battery used to power the kVp meter:

1. Be sure the power switch located on the front panel is in the OFF position.
2. Remove the battery cover, located on the rear panel, by pulling on the black access tab until the protective metal plate pops out.
3. If applicable, remove the used battery. Connect the new battery to the terminal connector following standard polarity conventions.
4. Place the battery into the housing so that the protective metal plate lies flat against the rear panel of the unit when placed over the battery.
5. Secure protective metal plate into place by pressing firmly on the black tab until it locks.

3.2 Detector Positioning

The kVp meter should be positioned so that the red detector area on the top panel of the unit is centered in the x-ray beam. The x-ray beam should cover at least the red portion of the case top to assure an accurate measurement. Placement of the kVp meter relative to the x-Ray tube is shown in Figure 3-1.

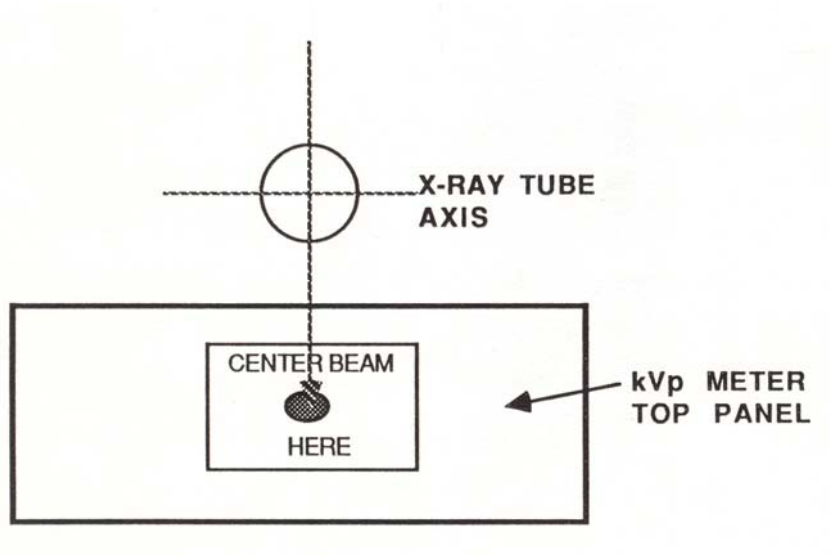

Figure 3-1. Detector Positioning

3.3 Determining mAs Requirements

The values in Table 3-1 are intended to guide the user in selecting the mAs required for a particular kVp measurement. Any mAs beyond the user-designated amount will not be included in the measurement. (Refer to Section 2 - Theory of Operation for a detailed discussion.)

NOTE

The values in Table 3-1 are derived from single-phase measurements. Three phase machines will generally require 70% of the mAs determined from the table.

mAs requirements may vary considerably depending on the following conditions:

1. Detector sensitivity
2. Tube filtration
3. Radiation Waveform
4. FDD
5. mAs errors in the x-ray machine

If this technique fails to produce a result, double the time (or decrease the FDD by 30%) and try again.

Table 3-1. mAs Requirements

kVp	20 cm		100 cm	
	Min mAs	**Max mA**	**Min mAs**	**Max mA**
45	8.42	109.92	209.94	2520.54
50	2.70	50.48	67.46	1261.42
60	0.452	6.318	11.30	157.96
70	0.226	2.342	5.66	58.58
80	0.0852	1.149	2.12	28.98
90	0.062	0.5688	1.55	14.2

Typically, the largest apparent variation in mAs requirements will be due to a kVp error. If doubling the mAs fails to produce a result, increase the kVp setting (or decrease the FDD) until a result is achieved.

3.4 Initial and Periodic Operation Checks

Generally it is not easy to verify the accuracy of the kVp meter in normal field usage. If care is taken, either of the methods outlined in the following sections can be used to verify performance of the meter. Both methods discussed require a careful collection of installation data and periodic measurement of that data.

Voltage Divider Method

Use the following procedure to perform initial and periodic operation checks of the kVp meter if an x-ray voltage divider is available:

1. Choose two x-ray systems suited for the test, preferably two different systems, i.e. three phase vs one phase, falling load vs not, etc. Choosing two dissimilar x-ray machines for the check reduces the possibility of systematic errors.

2. Make comparative measurements of the x-ray systems using the voltage divider and the kVp meter.

NOTE

If an oscilloscope is used to read the voltage divider, an independent voltmeter should be used to measure scope sensitivity before each operation check.

Data with a kVp test cassette would be useful. Note positioning error and film usage when applying the cassette.

3. At installation, record all parameters of the measurement in a bound notebook. Also record geometry, cable connections, tube I.D., generator I.D., divider and kVp meter oscilloscope waveform pictures, oscilloscope and voltmeter I.D., and any other information that may prove useful for periodic operation checks.
4. Periodically (every six months), or whenever a serious discrepancy in kVp operation is noted, the above tests should be repeated to determine if the unit is operating properly. The kVp meter, divider, cassette result, and x-ray settings should be examined for consistency.

Multiple X-Ray Machine Method

If a voltage divider is not available, use the following procedure to perform initial and periodic operation checks of the kVp meter:

1. Choose several x-ray systems suited for the test. If possible, choose at least two different systems, i.e. three phase vs one phase, falling load vs not, etc. Choosing dissimilar x-ray machines for the check reduces the possibility of systematic errors.
2. Make comparative measurements of the x-ray systems using the kVp meter.

   Data with a kVp test cassette would be useful. Note positioning error and film usage when applying the cassette.
3. At installation, record all parameters of the measurement in a bound notebook. Also record geometry, cable connections, tube I.D., generator I.D., kVp meter oscilloscope waveform pictures, oscilloscope I.D, and any other information that may prove useful for later periodic operation checks.
4. Periodically (every six months), or whenever a serious discrepancy in kVp operation is noted, the above tests should be repeated to determine if the unit is operating properly. The kVp meter, cassette result, and x-ray settings should be examined for consistency.

If the kVp meter suddenly produces different results from previous tests on a specific x-ray machine, then there is a strong probability that the kVp meter is operating properly. However, if all of the x-ray measurements suddenly change, then the kVp meter may be malfunctioning.

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Section 4
Indicators and Controls

4.1 Front Panel

See Figure 4-1 for front panel control and indicator location.

Numeric Readout

The front panel 3-½ numeric digit LCD readout displays the measurement data. Also indicated on the display are low battery, overrange kVp, underrange kVp, high mAs, and low mAs conditions as listed in

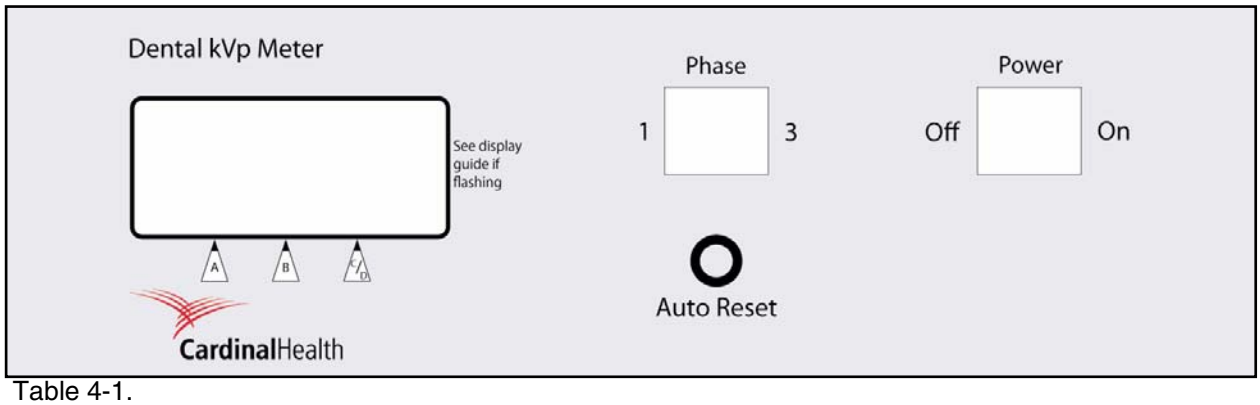

Table 4-1.

Figure 4-1. Front Panel Indicators and Controls

Table 4-1. Displayed Indications

Condition	Indication
Low Battery	LO BAT in the upper left corner of the display
Overrange kVp	Flashing decimal point directly above **A**
Underrange kVp	Flashing decimal point directly above **B**.
High mAs	Flashing decimal point directly above **C/D** and a non zero numeric display
Low mAs	Flashing decimal point directly above **C/D** and a display numerically equal to zero

An overrange kVp condition indicates that the measured kVp is above the calibrated range. An underrange kVp condition indicates that the measured kVp is below the calibrated range.

A high mAs condition indicates that the beam intensity is too high and the measurement is completed with less than 50 ms of the radiation waveform. The resulting measurements may be less accurate than those obtained with longer sample times. This is especially true in the case of single-phase x-ray machines where the radiation spectrum changes dramatically throughout the duration of a pulse. For example, if the measured waveform contains less than six pulses of single-phase rectification, then a partial pulse can have a significant contribution to the value of the average of the pulses. The effect is not as great for three phase machines because the radiation spectrum remains relatively constant throughout the exposure. To improve accuracy, the user should either increase distance or decrease the mA, both of which will reduce the beam intensity.

A low mAs condition indicates that the exposure is less than the required value to make a measurement. The user should either increase time or mA or decrease distance for the particular kVp setting. Refer to Section 3 for a discussion of minimum mAs requirements.

The auto reset on the front panel will turn on whenever the kVp meter detects an x-ray exposure. The LED will remain lit for 0.5 seconds or for the duration of the exposure, whichever is greater. The previous reading is cleared when the LED lights.

Switches

The power switch and the phase switch are located on the front panel. The power switch is used to turn the unit on or off. A phase switch allows selection for single phase and three phase applications.

4.2 Top Panel

The top panel of the kVp meter contains the following information:

- A brief set of operating instructions.
- An indication as to where to center the beam, referred to as the target.
- Display guide for **A**, **B**, **C**, and **D** decimal point indications as discussed above.

4.3 Rear Panel

The battery access panel and a BNC connector are located on the rear panel. Refer to Section 3 for battery replacement procedures. The BNC connector allows the user to connect an oscilloscope to the kVp meter to view the signal from the radiation detection diodes. The signal can be observed on the oscilloscope for the duration of the exposure. A storage scope or camera is necessary to view the signal for extended periods of time.

Section 5
Calibration and Adjustments

The Model 07-479 kVp Meter has been factory calibrated. Any calibration should be done by the factory or a qualified calibration facility. The unit should be calibrated once a year by adjusting the five variable resistors as discussed in the following sections.

5.1 Lo Battery Threshold Adjustment

Resistor R25 adjusts the threshold for the LO BAT indication on the LCD Display. Use the following procedure to adjust R25:

1. Remove the battery.
2. Connect a variable DC power supply to the instrument at the battery connector cable.
3. Connect a voltmeter between battery plus (TP3) and analog ground (TP4).
4. Turn on the power supply and adjust it to 9 V.
5. Turn on the kVp meter. The voltmeter should read between 2.4 and 3.2 V.
6. Slowly decrease the power supply until the voltage across the test points just returns to the value it had prior to dropping off.
7. Turn R25 until LO BAT disappears from the display.
8. Turn R25 slowly in the opposite direction just until LO BAT reappears on the display.
9. Connect the voltmeter between analog ground and the power supply negative terminal.
10. Increase the power supply voltage until the voltmeter reads 4.5 V while being careful not to exceed 9 V from the power supply. LO BAT should be off at this point.

5.2 kVp Calibration Adjustments

The following are some guidelines to ensure proper calibration of the kVp meter:

1. An independent accurate means of measuring the x-ray machines is necessary.
2. The kVp meter must be calibrated at 50 kVp and 90 kVp (± 1 kVp) if it is to be within specification over its entire range.
3. The phase switch must be in correct position during each portion of the calibration.
4. The potentiometers must be adjusted interactively as detailed below.
5. Be sure to follow the procedure outlined below in the order listed.

Use the following procedure for kVp calibration:

1. Set a calibrated dental x-ray machine to 50 kVp with sufficient mAs to obtain a reading.
2. Locate the Model 07-479 kVp meter in the center of the beam with the cover removed from the meter.

NOTE

Be sure the phase switch on the front panel of the kVp meter is in the appropriate position. Adjust R27 fully counter clockwise.

3. Make an exposure.
4. Adjust R6 (offset adjustment) until the kVp meter reads 50 kVp.
5. Set the x-ray machine to 90 kVp.
6. Make an exposure.
7. Adjust R5 (slope adjustment) until the kVp reads 90 kVp.
8. Repeat Steps 1 through 7 until the readings are accurate.

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